



California Energy Commission

Issues and Environmental Impacts Associated With Once-Through Cooling at California's Coastal Power Plants

***Prepared in Support of the
2005 Environmental Performance Report***

California Energy Commission Staff Report
Moss Landing Marine Laboratories
Industrial Economics, Incorporated
June 28, 2005



Once-Through Cooling

- Power Plant Cooling Technology Used by Over One Third of California Fleet
 - 21 plants totaling 23,910 MW
 - Nuclear, Steam Boilers, Combined Cycles
- Very Efficient Technology
- Reason for Coastal- and Estuarine-Based Power Plants
- Dates from 1950s
 - No scientific appreciation for impacts



Evolving Scientific Knowledge

- Near-Shore Oceans, Bays and Estuaries Sensitive and Productive Ecosystems
- Evolving Scientific Understanding
 - from Commercial Species to Ecosystem Approach
- Increasing Concern About General Impacts to Marine and Estuarine Ecosystems
 - Collapsing fisheries and polluted coastal waters
 - Over-fishing, pollution, development, non-point source
- Once-Through Cooling Emerging as Potential Major Contributor to Degraded Ocean and Estuarine Ecosystems



Convergence of Science, Regulation and Policy

- Two Major National Reports
 - US Commission on Ocean Policy
 - The Pew Ocean Commission
- Major Federal Regulatory Change
 - US EPA rulemaking on Section 316(b) of the Clean Water Act
- Major State of California Actions
 - Marine Life Management and Protection Acts (1998-99)
 - Ocean Protection Act (2004)
 - Ocean Protection Council (2005)
 - “Increase the abundance and diversity of aquatic life in California’s ocean, bays, estuaries and coastal wetlands”
 - Coordinate actions of state agencies and programs



Energy Commission Actions

- Develop Scientific Understanding
 - Push for baseline and plant-specific studies
 - PIER funding at Moss Landing research center - \$1.5 million
 - Raised in Environmental Performance Reports
- Assess State of Studies at All 21 Plants
 - Appendix 1: many power plants lack adequate studies
- 5 Repowering Cases Since 1999
 - Incorporate science into regulatory decisions
 - Balance emerging scientific understanding of impacts with re-use of existing infrastructure at coastal sites
 - Context of Energy Crisis and Deregulation
- Begin to Work with Ocean Protection Council



Purpose of Paper and Workshop

- Summarize Energy Commission Understanding of Science and Impacts
- Integrate CEC Knowledge into Broader Scientific Understanding of Impacts to Ocean and Estuarine Ecosystems
- Coordinate Energy Commission Initiatives with Other Agencies and Programs
- Develop and Offer Policy Options for Consideration of Commission



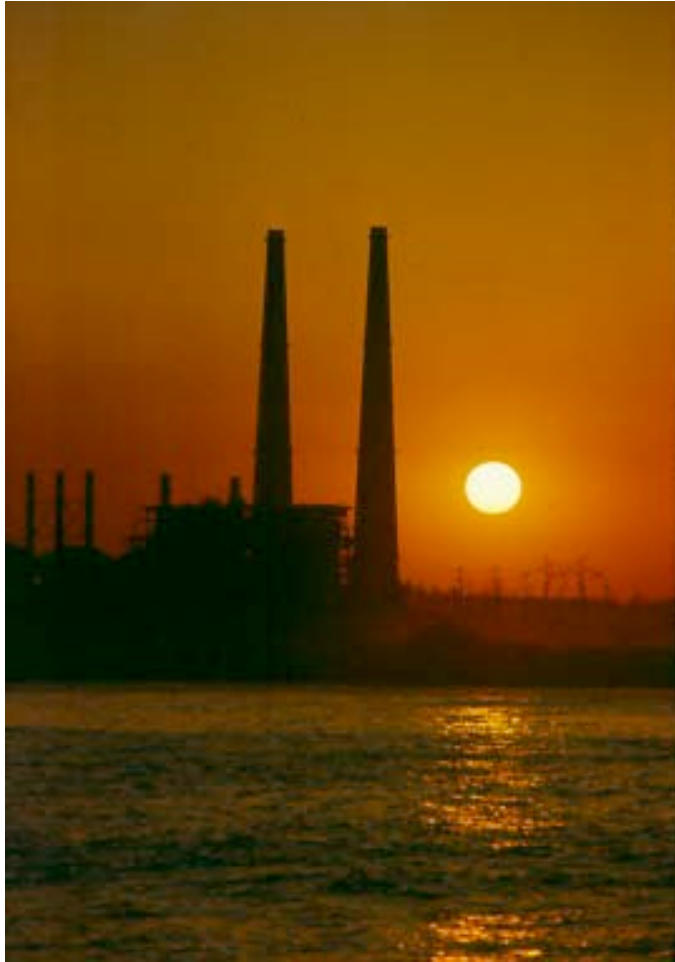
Workshop Agenda

- Energy Commission and Consultant Presentations
 - Dr. Michael Foster, Moss Landing Marine Labs
 - Caryn Holmes, Energy Commission Counsel
 - Robert Unsworth, Industrial Economics, Inc.
 - Rick York, Energy Commission Environmental Staff
- Stakeholder Panel Presentations
- Audience Comment



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ISSUES AND ENVIRONMENTAL IMPACTS ASSOCIATED WITH ONCE-THROUGH COOLING AT CALIFORNIA'S COASTAL POWER PLANTS

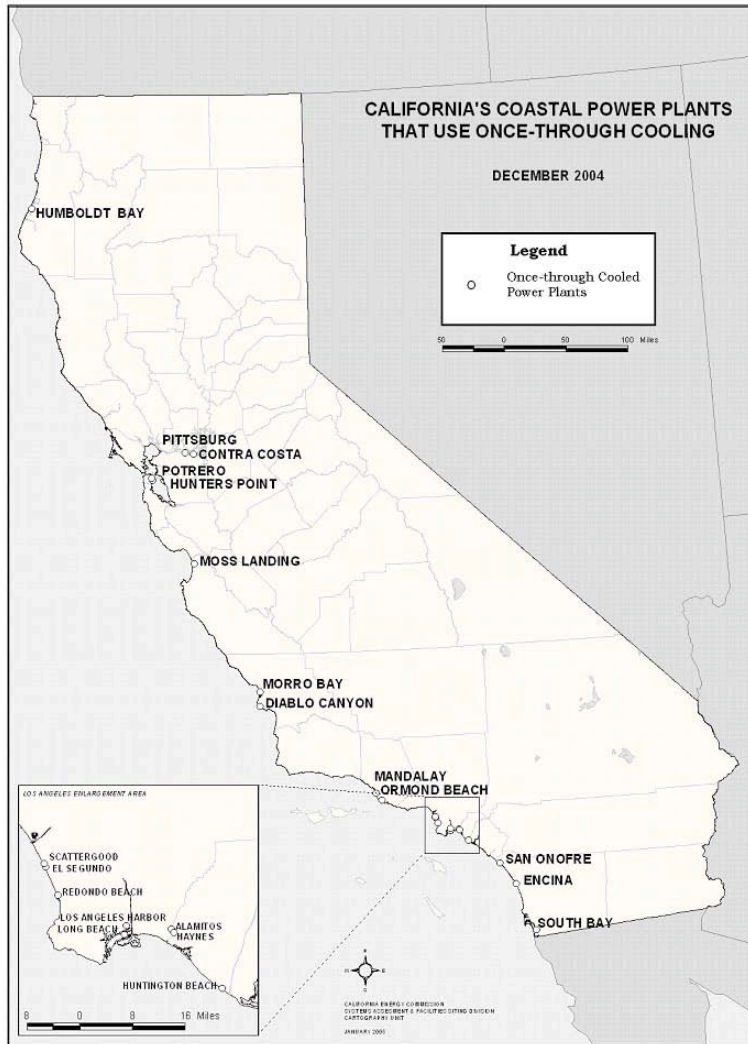


MAJOR MARINE IMPACTS

- pollution (nutrients, toxins, sediment)
- over fishing & by catch
- habitat destruction
- invasive species
- ocean warming & sea level rise
- once-through cooling?**



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21 Power Plants

Permitted To Use ~ 17 Billion
Gallons Per Day

Coast Sand/Rock (2)	5.12 BGD
Coast Sand/Harbor (6)	3.43 BGD
Bay/Estuary (13)	8.39 BGD



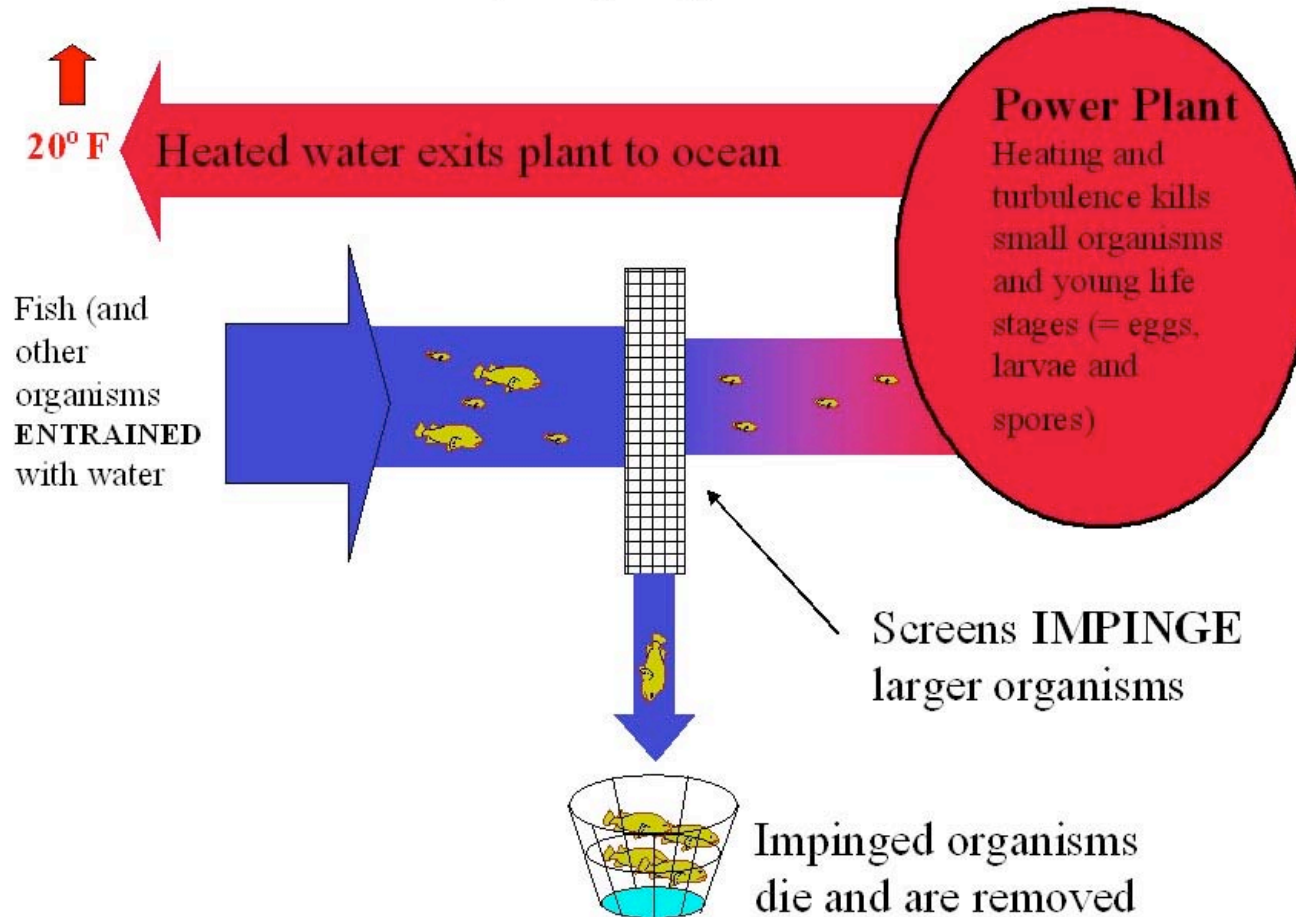
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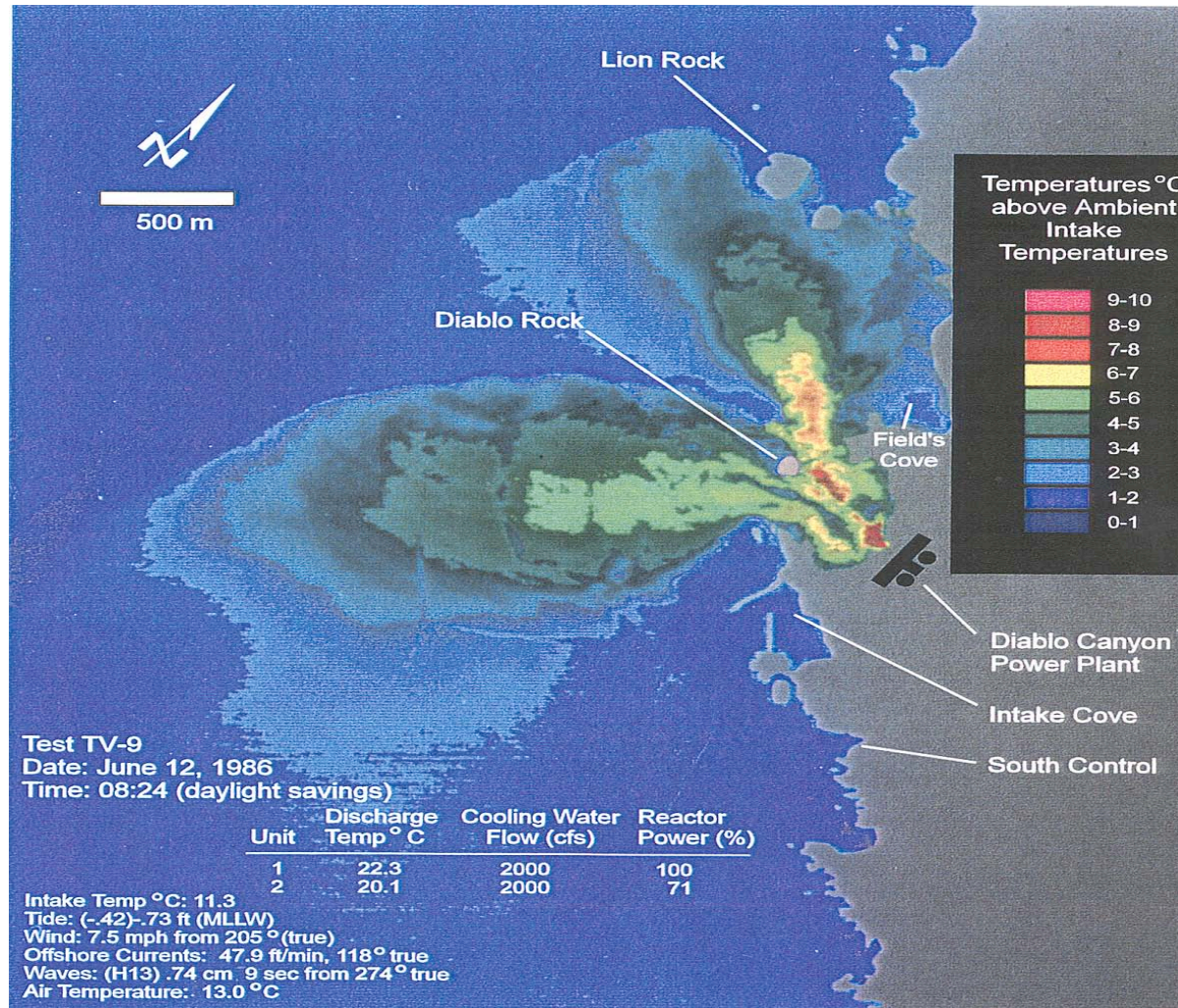
Thermal Effects, Impingement and Entrainment



(modified from Raimondi)



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Thermal Impacts – *very site specific but can be large*
- rock bottoms and enclosed waters

Before Discharge



After Discharge





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Impingement – *very site specific but can be large*
Southern California = 8-30% of Sport Fishing Catch
($> 90\%$ of this impingement by San Onofre)





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ENTRAINMENT

COASTAL AND ESTUARINE WATERS ARE HABITAT





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PLANKTON DIVERSITY (SPP, # species) & ABUNDANCE (#, #/1000 m³) IN CALIFORNIA COASTAL WATERS

Phytoplankton 10² SPP 10⁹ #



Zooplankton



	<u>SPP</u>	<u>#</u>
Adults		
1 Copepods and related animals	10 ²	10 ⁶
Larvae		
2 Crabs	8	3x10 ³
3 Clams & mussels	> 5	1.8x10 ⁸
4 Sea urchins	2	6x10 ²
5 Fish	44-200	400 – 600

~ 50 million marine & estuarine fish entrained per day in CA

Data from: phytoplankton, Petipa et al 1970; copepods, Hopcroft et al 2002; all other, Table 1.

1000 m³ x 10⁵ ≈ 17 BG



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ENTRAINMENT IMPACT ASSESSMENT

*Traditional:
Sample at Intake*



AEL & FH

Use No. of Larvae
Sampled to Estimate
No. of Adult
Equivalents Killed &
compare to fishery catch.

BUT how about impacts
to other species?

*Modern:
Also Sample Source Water*

1. Use Empirical Transport Model (ETM) to determine Proportional Mortality (PM) = proportion of larvae killed from entrainment that could be entrained (larvae in source population)
2. Determine area of source population
3. Determine average of 1.& 2. for species assessed ("target species")
4. Average PM x Average Area = area equivalent to 100% loss =
HABITAT PRODUCTION FOREGONE (HPF)
Representative of all species lost to entrainment



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Habitat Production Foregone

Hypothetical Example of a Power Plant in an Estuary. Entrainment Study Found:

1. Average Proportional Mortality of Estuarine Species = 17%
2. Area of Estuary = 2000 Acres (= source water; same for all species)

THEN: The Habitat Required to Compensate for Larval Losses (= New Estuarine Habitat Needed to Produce The Number of Larvae Equivalent to Entrainment Losses)

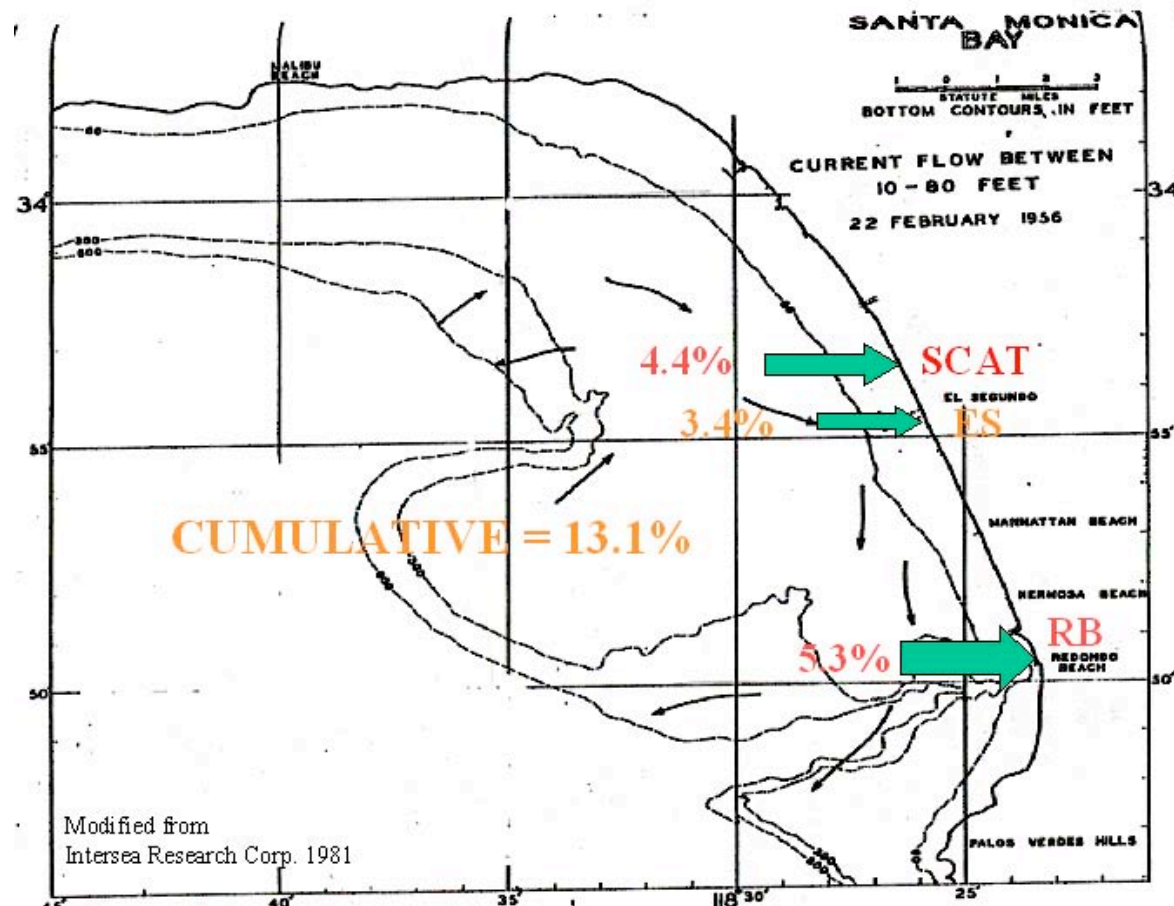
$$= (2000 \times 0.17) = \mathbf{340 \text{ Acres}}$$





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POTENTIAL CUMULATIVE IMPACTS SANTA MONICA BAY (% / 6 weeks)





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ENTRAINMENT IMPACTS FOUND IN RECENT STUDIES

	Original Study (1979-80)	Recent Study – Habitat Loss (1999-2004)
Moss Landing	no adverse	1100 acres - estuary
Morro Bay	no adverse	100-300 acres - estuary
Huntington	no adverse	$10^3 - 10^4$ acres - sandy coast *
Diablo Canyon	not reliable	300-600 acres - rocky reef
South Bay	no adverse	1000 acres - estuary

Projected Bay/Estuarine Habitat Production Foregone:

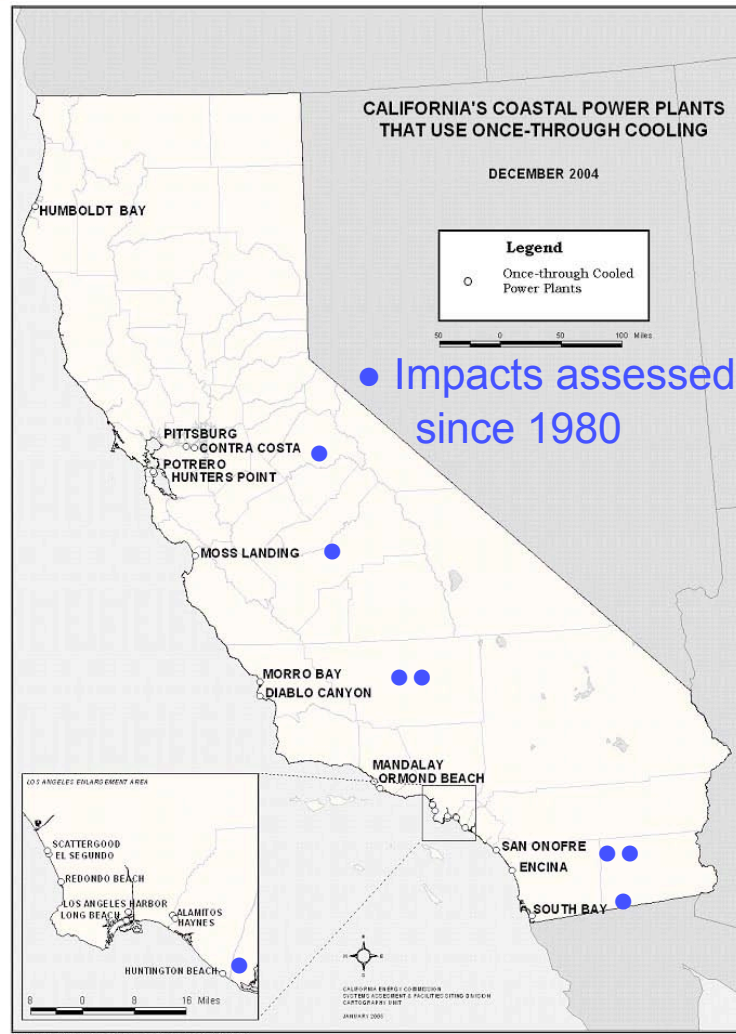
13 power plants, 8.39 BGD - 1.3 acres/MGD - \$114,000/acre

11,000 ACRES LOST ≈ \$1.2 BILLION TO RESTORE

* preliminary estimate



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13 Coastal Power Plants Lack Recent Entrainment Impact Assessments

- Accuracy of Original Assessments Unknown
- Out of Date

- NEED TO KNOW THESE IMPACTS
- ASSESSMENT IS A SCIENCE ISSUE
- NEED CONSISTENT STUDY APPROACHES AND INTERPRETATIONS, AND REVIEW BY UNBIASED EXPERTS



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MAJOR MARINE IMPACTS

- pollution
- over fishing & by catch
- habitat destruction
- invasive species
- ocean warming & sea level rise
- **once-through cooling**

**WHAT CAN THE CALIFORNIA
ENERGY COMMISSION DO TO
BETTER UNDERSTAND AND
REDUCE IMPACTS FROM
ONCE-THROUGH COOLING?**